Soils

This environmental assessment incorporates by reference (as per 40 CFR 1502.21) the Soils specialists report and other technical documentation used to support the analysis and conclusions of this environmental assessment. The entire report us in the project record which is located at the Sisters Ranger District office, Sisters, Oregon.

Introduction

The formation of different soil types are a result of five dominant, soil-forming processes, including climatic influences, soil and surface organisms, local topography/geomorphology, geology/parent materials, and time for soil development (Jenny 1941). The resulting soil characteristics uniquely integrate these local environmental influences and reflect the soil's inherent capacity for performing a variety of soil functions. These inherent soil qualities normally are not significantly altered by management activities and thus can be mapped and described in soil resource inventories. An understanding of the different inherent soil qualities, or soil potentials within a planning area, can be used to match different resource objectives to soils that have a high potential for achieving and sustaining those objectives over time. This in turn assures that management actions and the desired vegetation responses are both achievable and sustainable over time.

Dynamic soil quality, on the other hand, reflects how the soils functional capacity may be altered in response to natural or human caused disturbances (Seybold et al. 1999). Unlike inherent soil attributes, the dynamic characteristics of the soil are more vulnerable to changes from management actions that disturb soils. The long term sustainability of forest ecosystems depends on the maintenance of soil productivity and soils proper hydrologic functioning. Ground disturbing management activities that result from timber harvest and the treatment of fuels can directly affect soil properties, and may adversely change the natural functioning capacity of soils and their potential responses to use and management.

This analysis focuses on both inherent soil potentials as they relate to management objectives identified in the Melvin Butte project file and dynamic soil changes that have the potential to result in undesirable changes in key soil functions following vegetation management operations.

Issue Statement: Different soils vary in their inherent capacity for performing a variety of soil functions. Identification of the different inherent qualities of different soils within the Melvin Butte planning area can be used to help assure that planed management actions such as different stocking densities and amounts of retention are matched to soils that have a high potential for achieving the desired ecosystem functions (Issue Measure 1).

Issue Measure:

1. Recognition of the inherent soil qualities of different soil types and the ability to match different resource objectives such as stocking density prescriptions, amount of wildlife retention area, and prescribed fuel treatment prescriptions to soils that have a high potential for achieving and sustaining those objectives over time.

Issue Statement: The proposed use of ground based harvest equipment can potentially increase the amount and distribution of soil disturbance within individual activity areas proposed for vegetation treatments. The resulting soil disturbance from ground-based equipment operations and prescribed fire in activity areas may have the potential to negatively affect key soil functions (Issue Measure 2 and 3).

Issue Measures:

2. Change in degree, extent, distribution and duration of soil disturbance following proposed timber harvest and fuel treatments within individual activity areas proposed for mechanical treatments and assessment of effects of those disturbances on key soil functions.
3. The probable success in project design, implementation of management requirements, and mitigation measures that would be applied to minimize adverse impacts that may alter the soils ability to function in a desirable manner.

Regulatory Framework / Management Direction

Deschutes Land and Resource Management Plan

The Deschutes Land and Resource Management Plan (LRMP) specifies that management activities are prescribed to promote maintenance or enhancement of soil productivity potential following land management activities (US Forest Service LRMP, 1990 page 4-70, SL-1 and SL-3). Forest-wide standards and guidelines ensure that soils are managed to provide sustained yields of managed vegetation without impairment of the productivity of the land.

LRMP Standard and Guideline (SL-4) directs the use of rehabilitation measures when the cumulative impacts of management activities are expected to cause damage exceeding soil quality standards and guidelines on more than 20 percent of an activity area. LRMP Standard and Guideline (SL-5) limits the use of mechanical equipment in sensitive soil areas such as slopes greater than 30 percent. Operations would also be restricted to existing logging facilities (i.e., skid trails, landings) and roads whenever feasible.

Regional Soil Quality Standards and Guidelines

In addition to the LRMP Standards and Guidelines, the Pacific Northwest Region developed Regional Soil Quality Standards and Guidelines that limit detrimental soil disturbances associated with management activities (FSM 2520, R6 Supplement No. 2500-98-1). This Regional guidance supplements LRMP Standards and Guidelines and is designed to further protect or maintain soil productivity.

US Forest Service, Region 6, Regional Soil Quality Standards

When initiating new activities:

- Design new activities that do not exceed detrimental soil conditions on more than 20 percent of an activity area. (This includes the permanent transportation system).
- In activity areas where less than 20 percent detrimental soil impacts exist from prior activities, the cumulative amount of detrimentally disturbed soil must not exceed the 20 percent limit following project implementation and restoration.

- In activity areas where more than 20 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and restoration must, at a minimum, not exceed the conditions prior to the planned activity and should move conditions toward a new improvement in soil quality.

Detrimental soil impacts are defined as those that meet the criteria described in the Soil Quality Standards listed below.

- Detrimental Soil Compaction in volcanic ash/pumice soils is an increase in soil bulk density of 20 percent, or more, over the undisturbed level.
- Detrimental Soil Puddling occurs when the depth of ruts or imprints is six inches or more.
- Detrimental Soil Displacement is the removal of more than 50 percent of the A horizon from an area greater than 100 square feet, which is at least 5 feet in width.
- Severely Burned Soils are considered to be detrimentally disturbed when the mineral soil surface has been significantly changed in color, oxidized to a reddish color, and the next one half inch blackened from organic matter charring by heat conducted through the top layer.

The Regional supplement to the Forest Service Manual (FSM 2520, R6 Supplement No. 2500-98-1) also provides policy for planning and implementing management practices which maintain or improve soil quality. This Regional guidance is consistent with interpretations for LRMP Standards and Guidelines SL-3 and SL-4 that limit the extent of detrimental soil conditions within activity areas.

Analysis Methods

Method of analysis

Field observations and measurements of existing soil conditions within activity areas proposed for timber harvest and fuel treatments under this project were conducted during the fall field season of 2013.

Temporal scope of the analysis

The temporal scope of the analysis defines short term effects as being changes to soil properties that would generally revert to pre-existing conditions within 5 years or less. The analysis also considers the effectiveness and probable success of implementing project design criteria, mitigation measures, and Best Management Practices (BMPs) that are designed to avoid, minimize or reduce potentially adverse impacts to soil productivity.

Rational for geographic area of analysis

An activity area is defined as “the total area of ground impacted activity and its feasible unit for sampling and evaluating” (FSM 2520, R6 Supplement No. 2500-98-1 and Deschutes NF LRMP, page 4-71). For this analysis, activity area boundaries are considered to be the smallest identified area where the potential effects of different management practices would occur. Where appropriate and relevant, the effects discussion is expanded to the planning area to provide additional context and intensity.

Information sources used to support analysis

Quantitative analysis, literature reviews, and professional judgment were used to evaluate the issue measures by comparing existing conditions to the anticipated conditions that would result from implementing the proposed actions.

Measure #1: Identifying soils that have a high potential for achieving and sustaining different management objectives

Existing Condition

Soil types within the planning area are described and mapped in the Deschutes National Forest Soil Resource Inventory (Larsen 1976). A variety of different soils and landscapes occur within the planning area. These include limited areas of cinder cone buttes (SRI soil map units 80, 81, and 83). These buttes consist of very deep soils that developed in volcanic ash over cinder or fractured rock and occur on steep slopes (greater than 40%). The relatively high site productivity of these areas along with aspect changes result in a variety of vegetation types and different habitat potentials that are of limited extent in the planning area.

The remainder of the planning area consists of well drained soils derived from a moderately thick layer of volcanic ash over glacial till or bedrock. Surface soils are typically loamy sands, and subsoil's are cobbly to boulder sandy loams. A compact zone of glacial till is often encountered at a depth of 40 to 60 inches. These soils support a vegetation component of conifers including primarily white fir, ponderosa pine, and lodgepole pine. Understory shrubs and groundcover include snowbrush, manzanita, currant, snowberry, Oregon grape, sedges, pinegrass, and a variety of forbs (Figure 1).

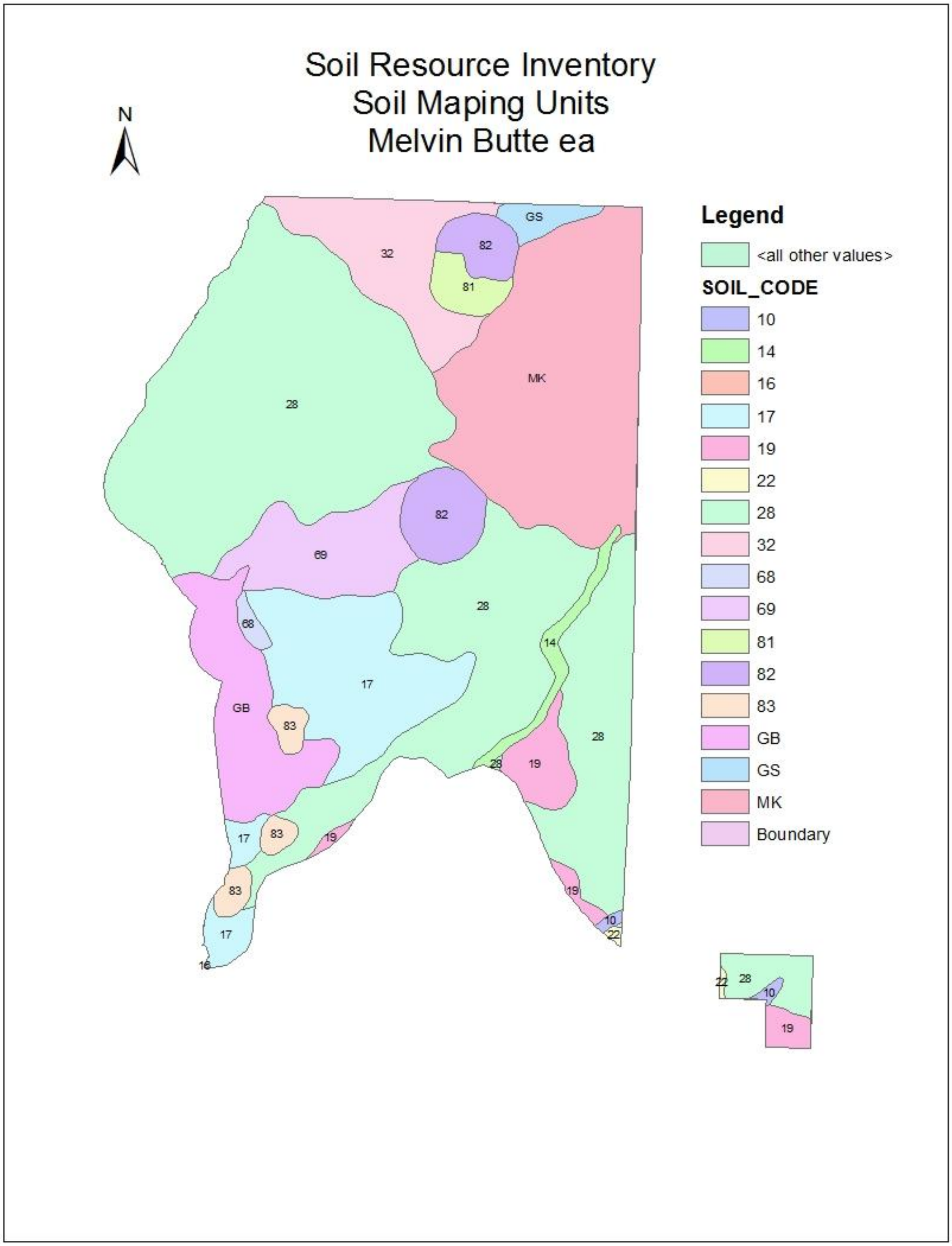

Figure 1: Soil types in the Melvin Butte planning referenced in the Deschutes National Forest Soil Resource Inventory (Larsen 1976).

In areas of ponderosa pine and mixed conifer species site productivity is estimated at a cubic foot Site Class 4 to 5 (50 to 120 cubic foot/year) mean annual increment, and a Site Index of 70 to 100 for ponderosa pine (Larsen 1976; Barrett 1978). In these dry east side forest types, water is the most limiting site factor limiting site productivity and site index (Larsen 1976). Figure 2 shows the increase in site index as a function of precipitation for several SRI soil types in the planning area. Site productivity also generally increases with elevation due to increasing precipitation (Larsen 1976).

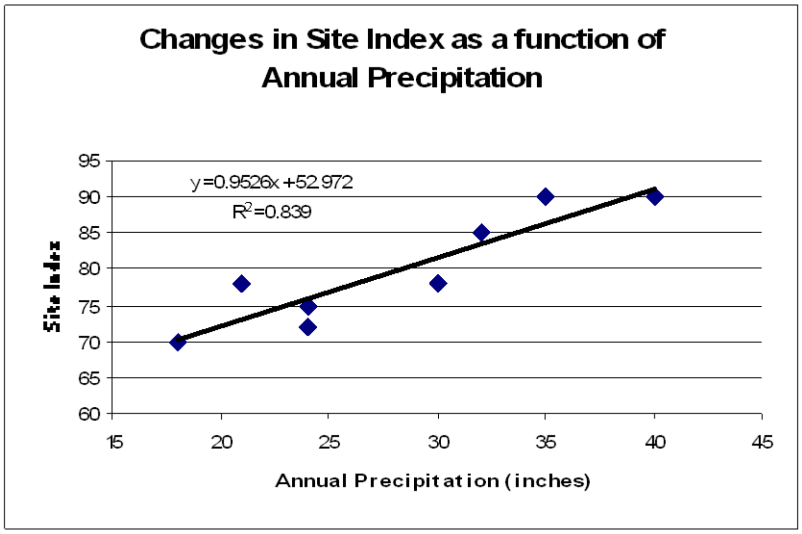

Figure 2: The relationship between mean annual precipitation and site index for selected SRI soil mapping units within the Melvin Butte planning area (Larsen 1976).

Lower Site Index Ponderosa pine Vegetation Potentials

Lower site index ponderosa pine soils include SRI soil map units 32,69, GS, MK, and 68 (Figure 3). These soils have a lower site index compared to other ponderosa pine soils in the planning area due to both lower precipitation in these areas and a lower soil water holding capacity of these soils. Soil mapping unit 32 is underlain by glacial till while soil units 69, GS, MK, and 68 are underlain by basalt bedrock. Areas with basalt bedrock have a highly variable in soil depths ranging from shallow to very deep. This variability in soil depth also has a strong influence on the pattern of tree clumps and gaps in these areas.

Higher Site Index Ponderosa pine Vegetation Potentials

SRI soil mapping unit 28 supports both ponderosa pine and mixed conifer vegetation types. These soils have a high site index due to a higher soil water holding capacity compared to other soils supporting ponderosa pine in the planning area. Productivity of areas of soil mapping unit 28 are also influenced by the increase in mean annual precipitation from north to south within the planning area. Higher precipitation in the southern portion of the planning area results in a higher productivity of soil type 28 compared to areas of soil type 28 in the northern portion of the planning area (Figure 3).

Frost Pocket Lodgepole pine Vegetation Potentials

SRI soil mapping units 17, 19, and GB occur in lower landscape positions compared to adjacent areas creating frost pockets that support lodgepole pine vegetation (Figure 3). Productivity is estimated to be a site index of 30 to 40 for lodgepole pine. Much of this area has been used for firewood cutting areas over the past couple of decades.

Applications to Project Planning

The different inherent soil productivities identified above were used to help in the design of the wildlife retention strategy for Melvin Butte planning area. This retention strategy is based upon increasing the amount of retention as site productivity increases. The planning strategy identifies ten percent retention in areas of lower ponderosa pine site index, fifteen percent retention in areas of high site index ponderosa pine, and 20 percent retention in areas of high site index ponderosa pine that also have higher precipitation.

During the project implementation phase silviculture prescriptions in treated areas and the resulting tree densities may also be adjusted slightly to reflect the above differences in inherent soil and site productivity.

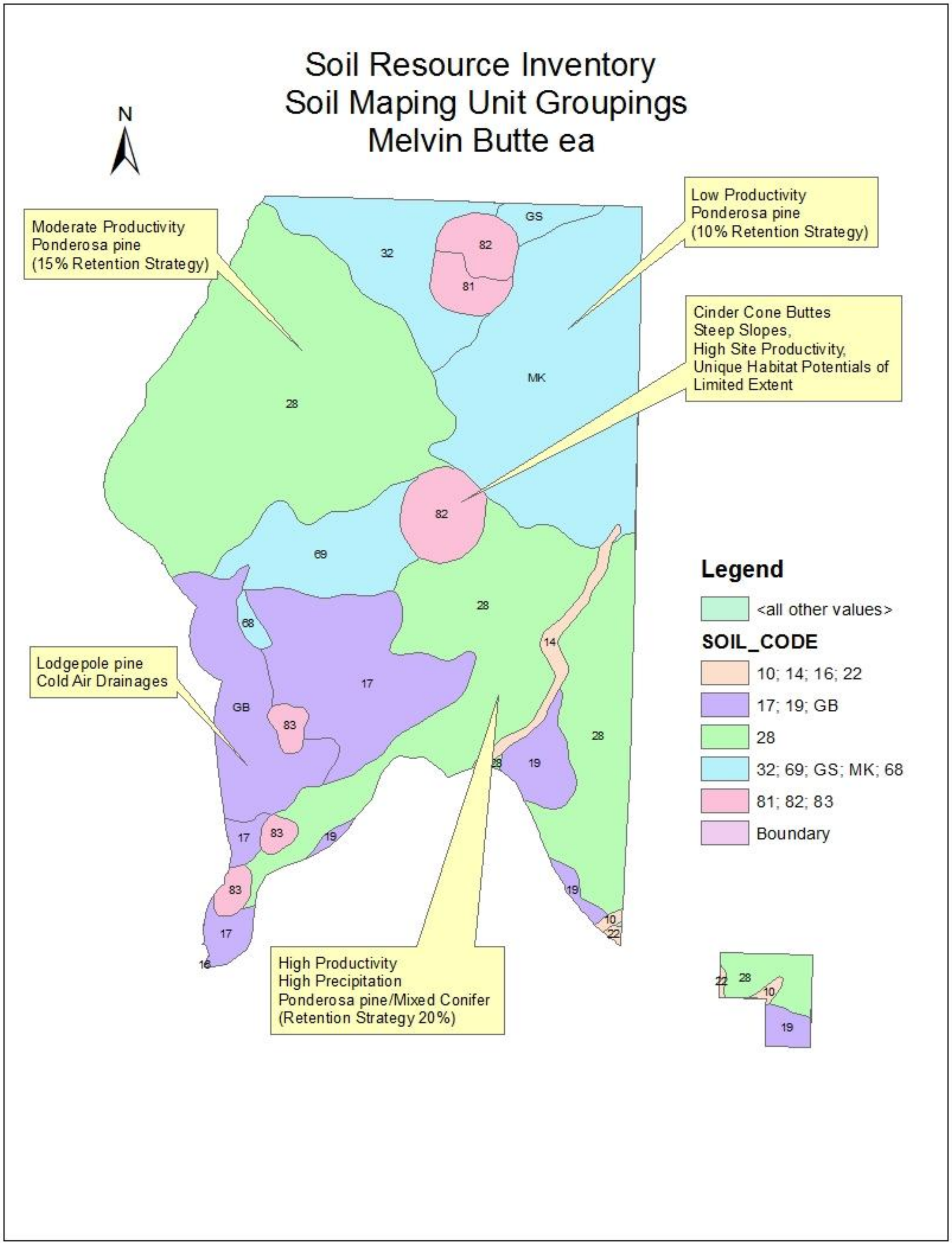

Figure 3: Deschutes National Forest Soil Resource Inventory soil mapping unit groupings indicating different vegetation types and the wildlife retention strategy based on site carrying capacity (Larsen 1976).

Measure #2: Soil Disturbance

Existing Condition

The current condition of soils in the Melvin Butte planning are directly related to soil porosity, soil strength, and the quantity and quality of surface organic matter within the project area (Powers and Avery 1995). Ground-disturbing management activities (i.e., timber harvest, road building, recreation use and livestock grazing) have all caused some adverse changes to soil quality in previously managed areas, especially where mechanical disturbances removed vegetative cover, displaced organic surface layers, or compacted soils. The following measures were used to evaluate the existing and predicted amounts of detrimental soil conditions for each individual activity area planned for treatment.

Ecological Trends – Alternative 1

Natural Events

There is currently no evidence of detrimental soil conditions from natural disturbance events within the Melvin Butte planning area. In 2012 the Pole Creek fire burned adjacent to the Melvin Butte planning area; however, no recent large wildfires have occurred within the planning area. Although fires have occurred in the planning area in the past enough time has passed since their occurrence that existing vegetation and forest litter are providing adequate source of ground cover to protect mineral soil from water and wind erosion. There are no recent natural or management related landslides within the planning area. Therefore, natural soil disturbances were not included as existing sources of detrimental soil conditions within any of the activity areas proposed for this project.

Management Related Soil Disturbances

The degree, extent, distribution and duration of soil disturbance can vary with the size and type of equipment used for forest vegetation management, the volume and type of material being removed, frequency of entries, soil type and the soil conditions when the activity takes place (Froehlich 1976, Adams and Froehlich 1981, Gent et al. 1984, Snider and Miller 1985, Clayton et al. 1987, Miller et al. 1986, Page-Dumroese 1993). Soil monitoring on local landtypes and similar soils have shown that typically around 15 to 20 percent of an activity area can be detrimentally disturbed by ground-based harvest systems (Craigg, 2000).

The primary sources of existing detrimental soil conditions are associated with the transportation systems used for timber harvest and yarding activities. Temporary roads, log landings, and the primary skid trails that were constructed and used to access individual harvest units of past timber sales. Most project related impacts to soils occurred on and adjacent to these heavy use areas. Mechanical disturbances include the removal of vegetative cover, displacement of organic surface soils, or compaction of the soil. Research studies and local soil monitoring have shown that soil compaction and soil displacement account for the majority of detrimental soil conditions resulting from ground based logging operations (Page-Dumroese 1993, Geist 1989, Powers 1999).

While prescribed burning does remove some of the surface organic matter, this process is a natural part of these ecosystems that historically experienced low intensity fire (Busse et al. 2014). These types of treatments also help to reduce the risk of impacts to the soil resource that can result from a high intensity uncharacteristic fire that could occur as a result of lack of active management.

Important Interactions

Harvest Operations

The proposed management activities include commercial and non-commercial harvest of forest stands combined with fuel reduction treatments to reduce stand densities and hazardous fuels. Types of mechanical harvest equipment used in thinning operations vary with the different logging companies doing the work and by the types of materials being removed. Thinning would include predominately trees in the smaller diameter classes. This may be accomplished manually using chainsaws or with the use of specialized low ground pressure machinery. Low ground presser machinery would only be allowed to make a limited number of equipment passes to transport material to roads or landings. In many cases created logging slash will be utilized as a source of biomass. In other cases created logging slash will be piled and burned. Management activities also include mechanical shrub and small tree treatments (mowing or mastication) and the use of prescribed fire to reduce fuel loadings and treat the shrub layer.

There would be no new construction of roads that would remain as classified system roads. Estimated distances of temporarily roads needed to allow access to some of the activity areas proposed for mechanical vegetation treatments are listed under the proposed action. Many of these spur roads would consist of reopening short segments (100-10,000 feet) of old access roads from previous entries. These roads would be closed and in some cases may be obliterated upon completion of the vegetation management activities.

The effects of ground based logging disturbances on soil productivity vary based on the soil type, types of silvicultural treatments, and the resulting amounts of ground disturbance. The cumulative amount of soil impacts also depends on the existing conditions prior to entry, the ability to reuse previously established landings and skid trail systems, types of equipment, amount of material removed from treatment areas, operator experience, and contract administration. Soil productivity monitoring on the forest has shown that detrimental soil conditions increase each time a stand is treated with mechanical equipment. Even with careful planning and implementation of project activities, the extent of soil disturbance has been shown to increase by 5 to 10 percent with each successive entry into a stand (Craigg, 2000).

Soil condition assessments for similar soils and types of harvest equipment, research references, local monitoring reports, planning area field surveys, and observation were used to predict the potential extent of detrimental soil disturbance associated with this project proposal (Craigg 2000; Craigg 2007). Estimates for predicted amounts of detrimental soil conditions account for the expected amount of volume removal, the type of logging equipment, the spacing of skid trails, and the number of log landings that would be needed to deck accumulated materials.

Fuel Reduction Activities

A combination of treatments including thinning trees from below, mechanical treatment of slash resulting from tree thinning operations, mechanical treatment of small trees and brush, biomass utilization, and prescribed burning would be used to reduce the fuel loading in the planning area.

Much of the slash generated from commercial harvest will be utilized for biomass. Common practices for removing biomass from harvest units include whole tree yarding and processing materials at the landing, and the removal of generated slash on forwarder trailers when harvester processers are used. If slash is not utilized for biomass it may be hand piled or machine piled and burned on log landings and/or main harvester trails. Machine piling on temporary roads or main harvest trails would not be expected to result in additional detrimental soil disturbance because equipment would operate on existing skid trails and landings.

Mechanical treatment of brush and small trees (mowing and mastication) is not expected to cause detrimental soil disturbances. The primary factors limiting soil compaction are the low ground pressure of the tractor and mowing heads, the limited amount of traffic (one equipment pass), and the cushioning effect of materials being treated. These types of activities have been monitored in the past, and results show that increases in soil displacement and soil compaction do not meet the criteria for detrimental soil conditions (Soil Monitoring Report, 1997).

Prescribed fire would be used to reduce fuel accumulations in some of the activity areas proposed for mechanical harvest and non-commercial thinning as well as other activity areas where prescribed burning would be used exclusively to treat the shrub layer and reduce natural fuels. Prescribed burning activities are conducted at times and under conditions that maximize benefits while reducing the risk of resource damage (Busse et al. 2014). The degree of soil heating depends upon fuel type (grass, brush, trees), fuel density, nature of the litter and duff layers (thickness, moisture content), and burn conditions at the time of ignition. For the treatment areas proposed with this project, natural fuel accumulations consist mainly of fine fuels (i.e., decadent brush, tree branches, and needle cast litter) that typically do not burn for long duration and cause excessive soil heating. Therefore, it is expected that there would be no detrimental changes in soil properties from prescribed burning activities in timber stands because soil moisture guidelines would be included in burn plans to minimize the risk for intense ground-level heating.

Prescribed burn plans would comply with all applicable LRMP standards and guidelines and Best Management Practices (BMP's) prior to initiation of burn treatments. Soil heating during spring burns would be negligible because higher moisture levels at this time of year generally result in cooler burns with lower potential for causing severely burned soil. Fall burning would be conducted following brief periods of precipitation. Prescribed underburns in timber stands would be accomplished under carefully controlled conditions to minimize damage to standing trees. These activities are planned to meet fuel and visual management objectives without removing all of the protective surface cover. It is expected that adequate retention of coarse woody debris and fine organic matter (duff layer) would still exist for protecting mineral soil from erosion and supplying nutrients that support the growth of vegetation and populations of soil organisms. The successful implementation of these proposed activities would likely result in beneficial effects by reducing fuel loadings and wildfire potential as well as increasing soil moisture and nutrient availability in burned areas.

The extent of disturbed soil resulting from the construction of control lines would be limited to the minimum necessary to achieve prescribed burning objectives. In most cases existing roads and other existing fuel breaks would be used to effectively control the spread of prescribed fire within treatment units.

Soil Restoration Treatments on Roads and Logging Facilities

Although equipment traffic during harvest operations can cause decreases in soil porosity and increases in soil resistance to root penetration. Compacted sites can be mitigated physically by tillage with a winged subsoiler (Powers, 1999). Many of the soils within the project area are well suited for tillage treatments due to their naturally low bulk densities and the absence of rock fragments within soil profiles. These sandy-textured soils have little or no structural development within the principal root development zone (4 to 12 inches in depth) where changes in soil compaction (bulk density) are assessed according to Regional direction (FSM 2521.03).

Under the action alternatives soil restoration treatments may be applied with a self-drafting winged subsoiler to reclaim and stabilize detrimentally compacted soil on specific roads and some of the primary skid trails and log landings following post-harvest activities. Additional treatment options for improving soil quality on disturbed sites include redistributing topsoil in areas of soil displacement damage and pulling available logging slash and woody materials over the treated surface.

The winged subsoiling equipment used on the Deschutes National Forest has been shown to lift and shatter compacted soil layers in greater than 90 percent of the compacted zone with one equipment pass (Craigg, 2000). Subsoiling treatments have been implemented with good success due to the absence of rock fragments on the surface and within soil profiles. Although rock fragments can limit subsoiling opportunities on some landtypes, hydraulic tripping mechanisms on this specialized equipment help reduce the amount of subsurface rock that could potentially be brought to the surface by other tillage implements. Most of the surface organic matter remains in place because the equipment is designed to allow adequate clearance between the tool bar and the surface of the ground for allowing smaller logging slash to pass through without building up. Any mixing of soil and organic matter does not cause detrimental soil displacement because these materials are not removed off site. Since the winged subsoiler produces nearly complete loosening of compacted soil layers without causing substantial displacement, subsoiled areas on this Forest are expected to reach full recovery within the short-term (less than 5 years) through natural recovery processes.

Although the biological significance of subsoiling is less certain, these restoration treatments likely improve subsurface habitat by restoring the soils ability to supply moisture, air, and nutrients that support soil microorganisms. Research studies on the Deschutes National Forest have shown that the composition of soil biota populations and distributions rebound back toward pre-impact conditions following subsoiling treatments on compacted skid trails and log landings (Moldenke et al., 2000).

Alternative 2 and 3
Direct and Indirect Effects –

The use of ground-based equipment for vegetation management treatments would increase the amount and distribution of soil disturbance within the proposed activity areas. However, through implementation of project design criteria intended to minimize soil disturbance and through the application of appropriate soil mitigation measures intended to protect soils, none of the activities areas are expected to exceed the Forest plan standard of 20% detrimental soil disturbance following proposed treatment (Appendix A). The development and use of temporary roads, log landings, and skid trail systems are the primary sources of new soil disturbance that would result in adverse changes to soil productivity. Most soil impacts would occur on and adjacent to these heavy-use areas where multiple equipment passes typically cause detrimental soil compaction. Mitigation and resource protection measures would be applied to avoid or minimize the extent of soil disturbance in random locations between main skid trails and away from log landings. Non-commercial thinning by hand felling small-diameter trees with chainsaws would not cause additional soil impacts because machinery would not be used for yarding activities.

Soil displacement from harvest activities occurs when soil organic layers are scraped or pushed away by equipment or gouged by logs during skidding operations. This type of soil disturbance is most likely to occur on the steeper portions of harvest units. In order to avoid soil displacement disturbance, activity area boundaries would be adjusted to prohibit equipment operations in portions of activity areas that contain extensive areas with slopes steeper than 30 percent (see project design criteria for description of operations within small areas of slopes greater than 30%). It is expected that many of these sensitive areas will be included as untreated patches within and adjacent to the proposed units to meet wildlife objectives. The majority of proposed activity areas are located on gentle to moderately sloping terrain where the maneuvering of equipment generally does not remove soil surface layers in areas that are at least 5 feet in width (FSM 2520). Smaller areas of soil displacement or the mixing of soil and organic matter would not constitute detrimental soil displacement. There would be no new construction of temporary roads or logging facilities on steep slopes or sensitive soils.

Mechanical shrub and slash treatments would be accomplished using low ground-pressure machinery and soil disturbance from these activities are not expected to qualify as a detrimental soil condition. The depth of compaction from only one or two equipment passes would not increase soil resistance and/or reduce soil porosity to levels that would require subsoiling mitigation to restore soil physical properties. The dominant sandy-textured soils within the project area are not susceptible to soil puddling damage due to their lack of plasticity and cohesion.

Prescribed burn plans would comply with all applicable LRMP standards and guidelines and Best Management Practices (BMPs) prior to initiation of burn treatments. Soil moisture guidelines would be included in burn plans to minimize the risk of intense ground-level heating. Duff moisture levels of approximately 50 percent are typical during light intensity underburns. Soil heating during spring burns would be negligible because higher moisture levels at this time of year generally result in cooler burns with lower potential for causing severely burned soil. Fall burning would be conducted following brief periods of precipitation. Prescribed underburns in timber stands would be accomplished under carefully controlled conditions to minimize damage to standing trees.

The amount of disturbed area associated with temporary roads and logging facilities would be limited to the minimum necessary to achieve management objectives. None of the temporary road locations would require excavation of cut-and-fill slopes because they are located on nearly level to gentle slopes. These temporary road segments would be closed and in some cases obliterated upon completion of the vegetation management activities.

Alternative 2 and 3
Cumulative Effects

Cumulative levels of existing and predicted amounts of soil disturbance need to be considered to determine whether soil quality standards (DNF LRMP 1990; FSM 2520, R-6 Supplement No. 2500-98-1) were met following project implementation. Based on the proportionate extent of overlap of previously disturbed areas and areas proposed for treatments, percentages of existing and predicted detrimental soil conditions were determined and are displayed in Appendix A of the soils specialist report.

Implementation of Alternatives 2 or 3 would cause some new soil disturbances where ground-based equipment is used for mechanical harvest and yarding activities during the current entry. The combined effects of past and current disturbances and those anticipated from implementing the proposed actions were previously addressed under existing conditions and in the discussion of direct and indirect effects. The primary source of detrimental soil conditions from past management are associated with existing roads and ground-based logging facilities which were used for past harvest activities. Likewise, the majority of project-related soil impacts from this entry would also be confined to known locations in heavy use areas (such as roads, log landings, and main skid trails). The net change in detrimental soil conditions is associated with additional logging facilities that would be retained following harvest or post-harvest soil restoration treatments.

Mechanical shrub and slash treatments would be accomplished using low ground-pressure machinery and soil disturbances from these activities are not expected to qualify as a detrimental soil condition. Slash disposal by hand piling and burning would not cause a measurable increase in detrimental soil conditions because machinery would not be used and burning small concentrations of slash materials is not expected to cause severely burned soil. Fuel reductions achieved through prescribed underburning in timber stands are conducted at times and under conditions that result in low-to-moderate intensity burns that do not cause detrimental changes in soil properties. No other projects are on-going or planning in the reasonable foreseeable future that may contribute to additional cumulative effects to soils.

Measure #3: Probable Success in Project Design and Implementation

Resource Protection Measures Common to the Action Alternatives

Best Management practices (BMPs) apply to all ground disturbing management activities, as described in the National Core BMP Technical Guide (US Forest Service BMP, 2012). The Deschutes National Forest Land Resource Management Plan (US Forest Service LRMP, 1990) states that BMPs will be selected and incorporated into project design criteria in accordance with the Clean Water Act for protection of waters of the State of Oregon (LRMP 4-69). The following guidelines will be used during project design to develop site-specific BMP prescriptions for harvest operations as appropriate or when required. These BMPs are referenced to the Soil and Water Conservation Practices (SWCP) Handbook (US Forest Service FSH 2509.22), which contains conservation practices that have proven effective in protection and maintaining soil and water resource values. In addition, they are referenced to the LRMP direction, BMP monitoring information, and professional judgment.

Alternative 2 and 3
Direct and Indirect Effects

Best management practices (BMPs), project design criteria (PCD), and resource protection measures common to the actions alternatives are all designed to avoid or minimize potentially adverse impacts to the soil resource during the implementation of management actions. Compliance with LRMP Standard and Guideline SL-5 is addressed by excluding heavy equipment from driving on sensitive soils on steeper slopes (greater than 30 percent). BMPs for timber management and road systems would be applied to protect the soil surface and control erosion on and adjacent to roads and logging facilities used during harvest operations. Soil disturbance resulting from proposed activities would be mitigated within the project area through the design of designated skid trails and limited off trail travel by equipment.

Alternative 2 and 3
Cumulative Effects

Cumulative effects for soils have incorporated past actions in the existing condition description as evidenced by the soil disturbance table (Soils Appendix A). The zone of influence for cumulative effects is limited to the harvest units. Effects are expected to be within allowable limits set by US Forest Service Region 6 Soil quality Standard Guidelines (FSM 2520, R6 Supplement No. 2500-98-1) and the Deschutes National Forest LRMP Standards and Guidelines (US Forest Service LRMP, 1990) for protecting and maintaining soil productivity within each of the proposed salvage units. There are no reasonable foreseeable future actions that would occur within the harvest units (effects from reforestation are not measureable); therefore there are no future cumulative effects.

Project Design Criteria and Best Management Practices

Project design criteria provide operational guidelines for equipment use in vegetation management operations and other ground disturbing activities, including prescribed fire. These operation guidelines include options for limiting the amount of surface area covered by logging facilities and controlling equipment operations to locations and ground conditions that are less susceptible to soil impacts. During the design of this project, these guidelines were discussed with operations personnel help ensue feasibility for implementation and design effectiveness.

US Forest Service, Region 6 provides Regional Soil Quality Standards (US Forest Service, 1991) that limit allowable detrimental soil disturbances associated with management activities. This Regional guidance supplements LRMP Standards and Guidelines and is designed to further protect or maintain soil productivity. Implementation of the project design criteria listed below will help ensure these standards are met.

In addition, Best Management practices (BMPs) apply to all ground disturbing management activities, as described in the National Core BMP Technical Guide (US Forest Service BMP, 2012). The Deschutes National Forest Land Resource Management Plan (US Forest Service LRMP, 1990) states that BMPs will be selected and incorporated into project design criteria in accordance with the Clean Water Act for protection of waters of the State of Oregon (LRMP 4-69). The following guidelines will be used during project design to develop site-specific BMP prescriptions for harvest operations as appropriate or when required. These BMPs are tiered to the Soil and Water Conservation Practices (SWCP) Handbook (US Forest Service FSH 2509.22), which contains conservation practices that have proven effective in protecting and maintaining soil and water resource values. They are also tiered to the LRMP direction, BMP monitoring information, US Forest Service Region 6 Soil Quality Standards, and best available science.

Project Design Criteria

BMP Veg-4. Ground-based Skidding and Yarding Operations

Objective: Avoid, minimize, or mitigate adverse effects to soil, water quality, and riparian resources during ground-based skidding and yarding operations.

Practices: Develop site-specific BMP prescriptions for the following practices, as appropriate or when required, using State BMPs, Forest Service regional guidance, land management plan direction, BMP monitoring information, and professional judgment.

- Use ground-based yarding systems only when physical site characteristics are suitable to avoid, minimize, or mitigate adverse effects to soil, water quality, and riparian resources (BMP Veg-4).
    - Avoid equipment operations on slopes greater than 30 percent (LRMP SL-2).
    - Assess sensitive soils to determine if equipment operations can occur without causing excessive soil disturbance (LRMP SL-3).
- Use suitable measures during felling and skidding operations to avoid or minimize disturbance to soils and water bodies to the extent practicable (BMP Veg-4).
    - Use directional felling techniques from pre-approved skid trails, and suspend the leading end of logs during skidding operations.
    - On steep pitches within a harvest unit (slopes of 30 percent or steeper) and less than 100 feet long, directional felling of trees to skid trails and/or line pulling should be utilized to harvest trees. This method applies to harvest units with small areas of steeper slopes (e.g. less than 5 percent of the unit area).
    - Stop harvest operations when soils become too wet to operate on without causing excessive soil disturbance.
- Use existing roads and skid trail networks to the extent practicable (BMP Veg-4).
    - Use old landings and skidding networks whenever possible. Assure that water control structures are installed and maintained on skid trials that have gradients of 10 percent or more. Ensure erosion control structures are stabilized and working effectively (LRMP SL-1).
- Design and locate skid trails and skidding operations to minimize soil disturbance to the extent practicable (BMP Veg-4).
    - In all proposed activity areas, locations of new yarding and transportation systems will be designated prior to the logging operations. This includes temporary roads, spur roads, log landings, and primary (main) skid trail networks (LRMP SL-1 & SL-3).
    - Designate locations for new trails and landings so that they properly fit the terrain and minimize the extent of soil disturbance (LRMP SL-3)
    - Restrict skidders and tractors to designated areas (i.e., roads, landings, designated skid trails), and limit the amount of traffic from other specialized equipment off designated areas. Harvester shears will be authorized to operate off designated skid trails at 30 foot intervals and make no more than two equipment passes on any site specific area to accumulate materials.
    - When using conventional harvest equipment that include harvester shears and rubber tired or tracked skidders, maintain spacing of 100 to 150 feet for all primary skid trail routes, except where converging at landings. Closer spacing due to complex terrain must be approved in advance by the Timber Sale Administrator and Soil Scientist. Main skid trails have typically been spaced 100 feet apart (11% of the unit area). For larger activity areas (greater than 40 acres) that can accommodate wider spacing distances, it is

recommended that distance between main skid trails be increased to 150 feet to reduce the amount of detrimentally disturbed soil to 7% of the unit area (Froehlich 1981).
    - When using harvester forwarder equipment space trails a minimum of 60 feet apart. Make use of ghost trails as much as possible on which the harvester makes only one pass and positions harvested materials so they can be reached from alternate harvester forwarder trails.
- Use suitable measures to stabilize and restore skid trails after use (BMP Veg-4).
    - Evaluate soil conditions and identify soil restoration opportunities (subsoiling) on skid trails post-harvest.

BMP Veg-6. Landings

Objective: Avoid, minimize, or mitigate adverse effects to soil, water quality, and riparian resources from the construction and use of log landings.

Practices: Develop site-specific BMP prescriptions for the following practices, as appropriate or when required, using State BMPs, Forest Service regional guidance, land management plan direction, BMP monitoring information, and professional judgment.

- Minimize the size and number of landings as practicable to accommodate safe, economical, and efficient operations (BMP Veg-6).
- Avoid locating landings near any type of likely flow or sediment transport conduit during storms, such as ephemeral channels and swales, where practicable (BMP Veg-6).
- Locate landings to minimize the number of required skid roads (BMP Veg-6).
- Re-use existing landings where their location is compatible with management objectives and water quality protection (BMP Veg-6).

BMP Veg-7. Winter Logging

Objective: Avoid, minimize, or mitigate adverse effects to soil, water quality, and riparian resources from winter logging operations.

Practices: Develop site-specific BMP prescriptions for the following practices, as appropriate or when required, using State BMPs, Forest Service regional guidance, land management plan direction, BMP monitoring information, and professional judgment.

- Conduct winter logging operations when the ground is frozen or snow cover and depth is adequate to avoid or minimize unacceptable rutting or displacement of soil (BMP Veg-7).
- Suspend winter operations if ground and snow conditions change such that unacceptable soil disturbance, compaction, displacement, or erosion becomes likely (BMP Veg-7).

BMP Fire-2. Use of Prescribed Fire

Objective: Avoid, minimize, or mitigate adverse effects of prescribed fire and associated activities on soil, water quality, and riparian resources that may result from excessive soil disturbance as well as inputs of ash, sediment, nutrients, and debris.

Practices: A burn plan addressing compliance with applicable DES LRMP standards and guidelines and BMP's will be completed before the initiation of prescribe fire treatments in planning activity areas. Prescribed burn plans need to include the following to protect soils and water quality.

- Conduct prescribed fires to minimize the residence time on the soil while meeting the burn objectives.
    - Manage fire intensity to maintain target levels of soil temperature, duff, and residual vegetation cover within the limits and at locations described in the prescribed fire plan (BMP Fire-2).
- Consider alternatives to ground-disturbing fireline construction such as using existing roads or other already existing suitable features for firelines.
    - If fireline construction is necessary, construct line to the minimum size and standard necessary to contain the prescribed fire and meet overall project objectives (BMP Fire-2).